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DETERMINATION OF THE OPTIMAL MEDIUM CONCENTRATION FOR UNABI FRUIT STORAGE

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Аннотация: В данной статей приведении результаты хранения унаби (*Ziziphus jujuba Mill.*), который хранили при температуре 1 °C в контролируемой атмосфере (5% O_2 и 0% CO_2, 10% O_2 и 0% CO_2, или динамический CA - 70% O_2 и 0% CO_2 в течение 7 дней, а затем перевод на 5% O_2) и при комнатной температуре 22 °C в качестве контроля. Определены оптимальные концентрации и сроки хранения атмосферных компонентов при хранении фруктов, а также были изучены изменения биохимического состава.

Annotation: This article presents the results of storing jujube (Ziziphus jujuba Mill.), which was stored at 1 °C in a controlled atmosphere (5% O2 and 0% CO2, 10% O2 and 0% CO2, or dynamic CA - 70% O2 and 0% CO2 for 7 days, and then converted to 5% O2) and at room temperature 22 °C as a control. Optimal concentrations and storage periods for atmospheric components during fruit storage have been determined, and changes in biochemical composition have been studied.

Ключевые слова: плоды унаби, контролируемая атмосфера, этилен, цвет плодов, летучие вещества.

Key words: jujube fruits, controlled atmosphere, ethylene, fruit color, volatile substances.

Introduction. Jujube (Ziziphus jujuba Mill.) is a highly nutritious and attractive fruit grown commercially in China. In recent years, jujube consumption, particularly fresh, has increased, further enhancing its commercial importance. The high respiration rate and climacteric nature of jujube accelerate quality deterioration and limit the availability of fresh-consumption cultivars in markets [1, 2].

Although the fruit can be stored at low temperatures for up to two months, it is highly perishable and susceptible to discoloration, browning, rotting, and dehydration after harvest [3]. Controlled atmosphere (CACE) at low temperatures has been shown to have a beneficial effect on various pathological and physiological problems that occur during fruit storage [4, 5, 6]. Short-term treatment with ultra-low oxygen (ULO) or high CO2 concentrations can be effective in controlling decomposition [7]. However, B. Dai [8] found that high O2 concentrations play an important role in preventing browning and rotting after harvest.

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In recent years, high oxygen treatment, also known as "oxygen shock" or "gas shock," has been used in postharvest processing of fruits and vegetables because it is beneficial in arresting physiological metabolism, preserving quality, and extending shelf life [5, 8]. The main objective of this study was to investigate the effects of different atmospheric conditions on the color, flavor, and shelf life of jujube fruits during storage.

Experimental Methods and Materials.

Fruit external color was determined using a minolta chromometer, fruit peel anthocyanin concentration was determined according to a modified method of Paul et al. (1985), chlorophyll content was determined using dimethylformamide (Moran, 1982), and potentiometric titration with titratable acid 0.1 mol/L NaOH to pH 8.1, and the concentration of soluble solids was determined using a refractometer. The data were examined using analysis of variance with a one-way general linear model (ANOVA). Differences between treatments were determined using Duncan's multiple-choice test at a significance level of 5%, and differences at $P \leq 0.05$ were considered statistically significant.

Junabi fruits were harvested in the first ten days of September from the orchard of the experimental farm of Tashkent State Agrarian University. The fruits were pre-chilled immediately after harvesting and then transported to the Kashkadarya region within 8 hours in a refrigerated truck at a temperature of 10°C. Healthy fruits were sorted and processed as follows: at a temperature of +1°C under CA conditions, including the CA I variant, 70% O2 + 0% CO2 was converted to 5% O2 + 0% CO2 for 7 days; CA II variant 5% O2 + 0% CO2; The CA III variant (10% O2 + 0% CO2) was also stored at room temperature (22°C) as a control. The chambers were equipped with controlled atmospheres (CA III) and connected to CO2 and ethylene absorbers and an atmospheric analyzer. The initial O2 and CO2 contents in the chambers were controlled by a flow system. N2 (100%) and O2 (99.5%) were mixed through pressure regulators and automatically controlled and regulated by the analyzer. In the CA chambers (temperature +1°C, relative humidity 95%), the fruits were packed in 8 kg boxes wrapped in polyethylene film (0.04 mm thick). Each variant was tested in three stages.

Experimental Results and Discussion

Peel Color. In the control variant (room temperature 22°C), the peel color of the jujube fruits quickly turned red, and the rate of reddening increased sharply from 25% at harvest to 75% after 7 days of storage. Similar, but less pronounced, results were observed in fruits stored in controlled atmospheres (Fig. 1).

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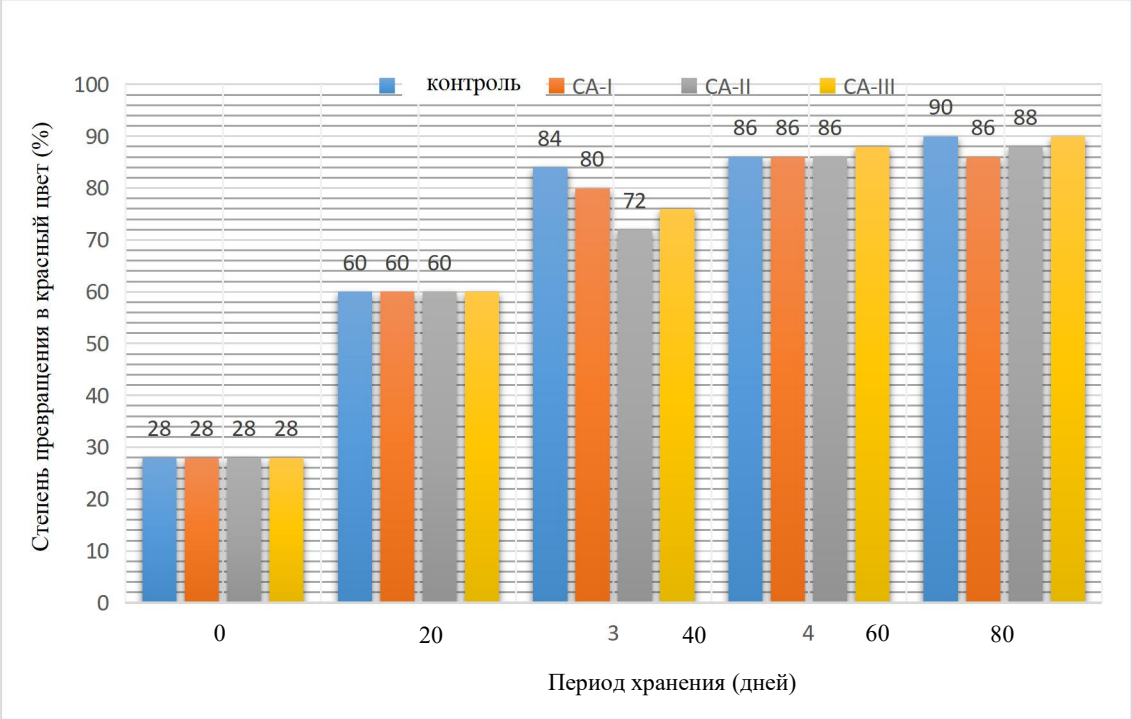


Figure 1. Degree of red coloration of jujube fruits during storage under various atmospheric conditions (%).

In the control sample (room temperature 22°C), the color of the jujube fruits became darker and redder over time, and their gloss decreased.

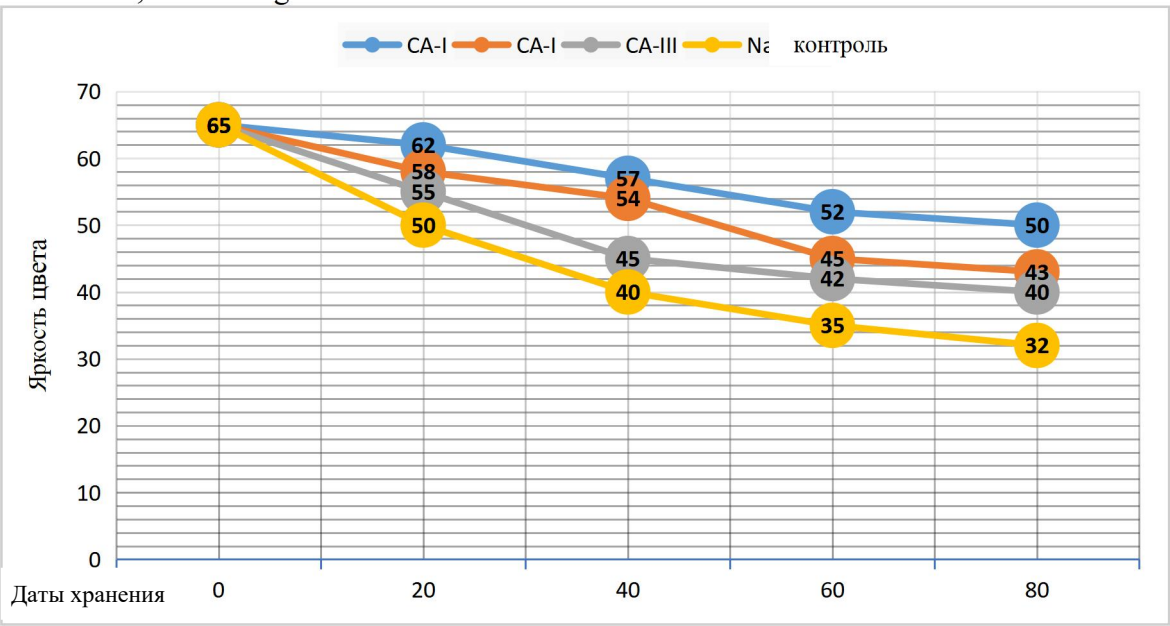


Figure 2. Changes in the external color of jujube fruits under different storage conditions.

In contrast, the color of jujube fruits treated with a high O2 atmosphere was brighter (high L* values), shinier (high C* values), and less reddish (high H angle) compared to other treatments during storage. This method showed a lower degree of browning of the fruit skin compared to other treatments (Figure 2).

Chlorophyll. The chlorophyll content of jujube fruits in the control variant (room temperature

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22°C) decreased rapidly from 45.2 mg/g to 26.5 mg/g after 20 days of storage (Table 1). Storage at low temperatures significantly reduced the decrease in chlorophyll in jujube fruits. In the first 20 days, 156.6% of chlorophyll was retained in the CA I variant, 152.0% in the CA II variant, and 153.2% in the CA III variant compared to the control; similar results were observed in the second 20 days. Unlike other treatments, high-oxygen treatment maintained high chlorophyll content until the 60th day of storage, after which a sharp decrease in chlorophyll content in the fruits was observed.

At the end of the storage period, the chlorophyll content in all variants decreased almost by half. This was due to the long shelf life. According to the experimental results, the high-oxygen treatment method was more effective than others. Processing methods.

Ethanol. In the experiment, after 80 days of storage of fresh chilanji fruits in the CA I treatment, the ethanol content increased from 102.17 nmol/g to 140.2 nmol/g, producing the highest amount of ethanol compared to other treatments. However, during storage for up to 40 days, it accumulated the least amount of ethanol and positively impacted the shelf life of the product. In the second treatment, in an atmospheric environment of 5% O2 / 0% CO2, the ethanol content increased from 102.17 nmol/g to 130.2 nmol/g, but accumulated 10 nmol/g less ethanol than in treatment I. Among all treatment methods for reducing ethanol accumulation, the most effective was the method with a content of 120.1 nmol/g in fruits stored in a controlled atmosphere of 10% O2 and 0% CO2. The low ethanol content in the fruits increases the potential for long-term fresh storage.

Biochemical changes during storage of jujube fruits of the Dong Zao variety in a controlled atmosphere environment (2023-2025)

Table 1

Days	Control variant	Option CA I	OptionCA I	OptionCAIII
Content of soluble solids (g/% per 100 g of fresh mass)				
1	23,6±0,4	23,6±0,4	23,6±0,4	23,6±0,4
20	29,5±0,4	23,6±0,4	23,6±0,4	23,6±0,4
40	inappropriate	26,0±0,4	23,6±0,4	24,1±0,4
60	inappropriate	26,0±0,4	25,0±0,4	25,0±0,4
80	inappropriate	25,0±0,4	25,0±0,4	25,0±0,4
Titratable acidity (mg/g fresh weight)				
1	0,41±0,06	0,41±0,06	0,41±0,06	0,41±0,06
20	0,37±0,06	0,40±0,06	0,40±0,06	0,40±0,06
40	inappropriate	0,40±0,06	0,41±0,06	0,45±0,06
60	inappropriate	0,48±0,06	0,46±0,06	0,46±0,06
80	inappropriate	0,40±0,06	0,41±0,06	0,42±0,06
Chlorophyll (mg/g fresh weight)				
1	45,2±0,5	45,2±0,5	45,2±0,5	45,2±0,5
20	26,5±0,5	41,5±0,5	40,3±0,5	40,6±0,5
40	inappropriate	37,0±0,5	31,6±0,5	34,5±0,5
60	inappropriate	35,6±0,5	29,1±0,5	26,1±0,5
80	inappropriate	20,1±0,5	26,1±0,5	26,4±0,5
Ethanol (nmol/g fresh weight)				
1	102,1±0,05	102,1±0,5	102,1±0,5	102,1±0,5
20	50±0,05	98,3±0,5	103,7±0,5	98,3±0,5

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40	inappropriate	91,6±0,5	106,2±0,5	93,1±0,5
60	inappropriate	125,1±0,5	118,4±0,5	89,2±0,5
80	inappropriate	140,2±0,5	130,2±0,5	120,1±0,5
Ethyl acetate (nmol/g fresh weight)				
1	12,1±0,4	12,1±0,4	12,1±0,4	12,1±0,4
20	7,1±0,4	19,6±0,4	17,3±0,4	32,4±0,4
40	inappropriate	25,3±0,4	21,6±0,4	53,8±0,4
60	inappropriate	25,7±0,4	28,3±0,4	32,1±0,4
80	inappropriate	10,5±0,4	5,2±0,4	5,6±0,4

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Ethyl acetate. During storage of chilanji fruits in the control variant (room temperature 22°C) for 20 days, the ethyl acetate content increased from 12.1 nmol/g to 25.2 nmol/g. Quality indicators such as structure, color, and taste of the fruits also decreased, and they became unsuitable for consumption. When analyzing fruits in the subsequent 40 days, the ethyl acetate content in the CA-I and CA-III variants showed an increase of 21.6 and 53.8 nmol/g, respectively, while the CA-II variant showed the lowest level of 21.6 nmol/g ethyl acetate, which positively affected the quality of the fruits. Fruits stored in an environment with a controlled atmosphere of 10% O2 and 0% CO2 had a significantly higher ethyl acetate content than others after 40 days of storage, and then rapidly decreased. After 60 days of storage, the CA-I, CA-II, and CA-III variants showed 25.7; 28.3; A strong upward trend was observed from 53.8 nmol/g, but after 80 days of storage, the ethyl acetate content decreased in all variants.

Soluble Solids and Titratable Acidity. The soluble solids content of fruits stored at room temperature (22°C) gradually increased over time, reaching 23.6% at harvest and 29.5% after 20 days. Although the soluble solids content of all fruits stored in an atmospheric environment varied between 23.6 and 26.0%, no significant differences were observed. Furthermore, different storage conditions did not significantly affect the amount of titratable acids.

Conclusion. Short-term treatment with high oxygen (70%) was found to be the most effective method for preserving fruit peel color, anthocyanin, and chlorophyll content, and preventing peel browning compared to other methods. Under control atmosphere (CA) conditions, ethanol content in fruits stored with 10% O2 and 0% CO2 was significantly lower, while a control atmosphere with 5% O2 and 0% CO2 effectively reduced ethyl acetate content throughout storage. Low ethanol and ethyl acetate content in fruits allows for high-quality, long-term freshness.

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